

WHAT IS CLAIMED IS:

1. A semiconductor optical device, comprising:
a substrate;
first and second semiconductor side regions formed over the substrate, a height of the first side region above the substrate being different from a height of the second side region above the substrate; and
a semiconductor ridge disposed between the first and second side regions and over the substrate forming an optical waveguide within the device, a height of the semiconductor ridge above the substrate being greater than the heights of the first and second side regions above the substrate.
2. A device as recited in claim 1, further comprising an active semiconductor region formed between the ridge and the substrate, the ridge guiding light amplified in the active semiconductor region.
3. A device as recited in claim 1, further comprising an electrode disposed over the ridge to inject current into the ridge.
4. A device as recited in claim 1, wherein the device comprises a semiconductor laser.
5. A device as recited in claim 1, further comprising a frequency selector optically coupled to the active region.

6. A device as recited in claim 5, wherein the frequency selector is a fiber Bragg grating coupled to an optical output from the semiconductor laser.

7. A device as recited in claim 1, wherein the first and second side regions define an average side region height above the substrate, and a kink current of the laser is higher than where the heights of the first and second side regions above the substrate are both equal to the average side region height.

8. A device as recited in claim 1, further comprising a current controller coupled to inject current through the ridge.

9. A device as recited in claim 1, wherein the substrate is thermally coupled to a cooler to remove heat from the substrate.

10. A device as recited in claim 9, wherein the cooler includes a thermoelectric cooler, and further comprising a cooler controller coupled to control operation of the thermoelectric cooler.

11. A device as recited in claim 1, further comprising at least one bond pad disposed on at least one of the first and second side regions, an electrode over the ridge being electrically coupled to the at least one bond pad, and a submount attached to the substrate, the submount being coupled to a laser carrier.

12. An optical communications system, comprising:
an optical transmitter;
a fiber optic link coupled to receive optical signals from the optical transmitter;
an optical receiver coupled to the fiber optic link to receive the optical signals; and

a laser coupled to inject light into the fiber optic link, the laser including

a substrate;

first and second semiconductor side regions formed over the substrate, a height of the first side region above the substrate being different from a height of the second side region above the substrate; and

a semiconductor ridge formed between the first and second side regions and over the substrate to introduce an optical waveguide within the device, a height of the semiconductor ridge above the substrate being greater than the heights of the first and second side regions above the substrate.

13. The system as recited in claim 12, wherein the laser is disposed within the optical transmitter.

14. The system as recited in claim 12, wherein the fiber optic link includes at least one fiber amplifier unit having a length of fiber amplifier, the at least one fiber amplifier unit including the laser coupled to inject pump light into the length of fiber amplifier.

15. The system as recited in claim 12, wherein the laser includes a frequency selector to select an output wavelength of pump light generated by the laser.

16. The system as recited in claim 12, wherein the optical transmitter includes control circuitry to control operation of one or more transmitter lasers within the optical transmitter and one or more respective modulator units to receive incoming information and modulate the incoming information onto light produced by the one or more lasers.

17. The system as recited in claim 12, wherein the optical transmitter includes at least two lasers operating at different wavelengths and a wavelength multiplexing unit to multiplex output light from the at least two lasers into a single output signal.

18. The system as recited in claim 12, wherein the optical receiver includes a wavelength demultiplexing unit to separate the optical signals into components of different wavelength, and respective detectors to detect signals at the different wavelengths.

19. A semiconductor laser, comprising:

a substrate having an upper surface, a lateral direction being defined parallel to the upper substrate surface;
one or more superstrate layers provided on the substrate; and
an optical waveguide disposed over the substrate to guide light passing between ends of the substrate and defining a fundamental optical mode, first and second sides of the optical waveguide providing optical confinement in the lateral direction, the optical confinement for the fundamental optical mode provided on the first side of the optical waveguide being different from the optical confinement provided on the second side of the optical waveguide.

20. A laser as recited in claim 19, wherein the waveguide includes a ridge waveguide formed from a semiconductor ridge disposed along the substrate.

21. A laser as recited in claim 20, wherein a depth of the optical waveguide relative to a base of the semiconductor ridge on the first side of the

optical waveguide is different from a depth of the optical waveguide relative to a the base of the ridge on the second side of the optical waveguide.

22. A laser as recited in claim 20, further comprising an electrode disposed over the ridge to inject current into the ridge.

23. A laser as recited in claim 19, further comprising a frequency selector optically coupled to the optical waveguide.

24. A laser as recited in claim 23, wherein the frequency selector is a fiber Bragg grating coupled to an optical output from the semiconductor laser.

25. A laser as recited in claim 19, wherein the first and second sides of the optical waveguide define an average waveguide confinement, and a kink current of the laser is higher than where the first and second sides of the optical waveguide each provide the average waveguide confinement.

26. A laser as recited in claim 19, further comprising a current controller coupled to inject current through the ridge.

27. A laser as recited in claim 19, wherein the substrate is thermally coupled to a cooler to remove heat from the substrate.

28. A laser as recited in claim 27, wherein the cooler includes a thermoelectric cooler, and further comprising a cooler controller coupled to control operation of the thermoelectric cooler.

29. An optical communications system, comprising:
an optical transmitter;

a fiber optic link coupled to receive optical signals from the optical transmitter;

an optical receiver coupled to the fiber optic link to receive the optical signals; and

a laser coupled to inject light into the fiber optic link, the laser including

a substrate;

one or more superstrate layers provided on the substrate;

and

an optical waveguide disposed over the substrate to guide light passing between ends of the substrate and defining a fundamental optical mode, first and second sides of the optical waveguide providing optical confinement in the lateral direction, the optical confinement for the fundamental optical mode provided on the first side of the optical waveguide being different from the optical confinement provided on the second side of the optical waveguide.

30. The system as recited in claim 29, wherein the laser is disposed within the optical transmitter.

31. The system as recited in claim 29, wherein the fiber optic link includes at least one fiber amplifier unit having a length of fiber amplifier, the at least one fiber amplifier unit including the laser coupled to inject pump light into the length of fiber amplifier.

32. The system as recited in claim 29, wherein the laser includes a frequency selector to select an output wavelength of pump light generated by the laser.

33. The system as recited in claim 29, wherein the optical transmitter includes control circuitry to control operation of one or more transmitter lasers within the optical transmitter and one or more respective modulator units to receive incoming information and modulate the incoming information onto light produced by the one or more lasers.

34. The system as recited in claim 29, wherein the optical transmitter includes at least two lasers operating at different wavelengths and a wavelength multiplexing unit to multiplex output light from the at least two lasers into a single output signal.

35. The system as recited in claim 29, wherein the optical receiver includes a wavelength demultiplexing unit to separate the optical signals into components of different wavelength, and respective detectors to detect signals at the different wavelengths.

36. A method of forming a semiconductor device having an asymmetric ridge, comprising:

removing material on a first side of a ridge region to a first depth;
and

removing material on a second side of the ridge region to a second depth different from the first depth, so as to produce the asymmetric ridge waveguide in the ridge region.

37. A method as recited in claim 36, further comprising masking the material on the second side of the ridge region before removing the material on the first side of the ridge region.

38. A method as recited in claim 37, further comprising masking the first side of the ridge region before removing the material on the second side of the ridge region.

39. A method as recited in claim 36, further comprising disposing photoresist over the ridge region and over material on the first and second sides of the ridge region, exposing the photoresist over the material on the first side of the ridge region to a first amount of light and exposing the photoresist over the material on the second side of the ridge region to a second amount of light different from the first amount of light.

40. A method as recited in claim 39, further comprising placing a first mask over at least the first and second sides of the ridge region and exposing the photoresist over the material on the first and second sides of the ridge region includes illuminating the first mask with exposing light.

41. A method as recited in claim 39, further comprising removing the photoresist over the material on the first side of the ridge region while leaving at least a portion of the photoresist over the material on the second side of the ridge region, and removing at least some material on the first side of the ridge region.

42. A method as recited in claim 41, wherein removing the at least some material on the first side of the ridge region includes removing material on the first side of the ridge region to a differential depth.

43. A method as recited in claim 41, further comprising removing the photoresist over the material on the second side of the ridge region after removing the at least some material on the first side of the ridge region.

44. A method as recited in claim 43, further comprising removing material from both the first and second sides of the ridge region after removing the photoresist over the material on the second side of the ridge region.

45. A method as recited in claim 36, further comprising forming at least one active layer under the asymmetric ridge.

46. A method as recited in claim 36, further comprising forming a laser cavity around the active layer under the asymmetric ridge.

47. A method as recited in claim 36, further comprising illuminating the first and second sides of the ridge region through a mask, the first side of the ridge region being illuminated through the mask by light having a first energy density and the second side of the ridge region being illuminated through the mask by light having a second energy density different from the first energy density.

48. A method as recited in claim 47, wherein illuminating the first and second sides of the ridge region through the mask includes asymmetrically exposing a photosensitive layer relative to the ridge region.

49. A method as recited in claim 48, further comprising removing material first from one side of the ridge region and then from both sides of the ridge region to form the asymmetric ridge in the ridge region.